STATE OF CALIFORNIA / THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

FLOOD FIGHTING METHODS

Division of Flood Management
Flood Operations Branch

Revised August 2003

FLOOD FIGHTING METHODS ON LEVEES AND ALONG RIVER BANKS

The main causes of levee failure during periods of high water are:

1. Seepage through or under the levee heavy enough to cause a “boil”. This can be caused by burrowing animals or decomposing tree roots.

2. Erosion of the levee due to swift moving water or wave action.

3. Overtopping resulting from river water-surface elevations higher than the levee.

The emergency measures used to prevent levee failure from these causes are known as “Flood Fight Methods.” The flood fight methods described in this booklet have proven effective during many years of use by the Department of Water Resources, Division of Flood Management and the United States Army Corps of Engineers. However, all measures shown are temporary and cannot be expected to last for extended periods of time.

Structures other than levees may also require flood protection.

Levee Patrol

When water levels reach a predetermined height (Monitor Stage), two person mobile patrols should be assigned to those areas for observation. Patrols should look for wavewash, boils, seepage, cracks, or sloughing. Personnel should maintain communications with the local Incident Command Post (ICP) and report problem areas too large or time consuming to repair with the minimal amount of flood fight equipment and material carried in patrol vehicles.

Filling Sandbags

When filling sandbags you should work in pairs, with one person holding the bag while the other shovels in the fill material. The first shovel of fill should be placed on the lip of the bag to help hold the bag open. The bag holder should find the most comfortable position while holding the bag open.

Figure 1

•The most common mistake made is overfilling bags. The shoveler should use rounded scoops of fill until the bag is approximately 1/3 full. While shoveling or holding, avoid extra movements (turning or twisting of the back) to prevent injury.

Sandbag Construction

The use of sandbags is a simple but effective method of preventing or reducing damage from floodwater and debris. (see Figure 2) Suggestions for constructing sandbag structures are:

1. Close weave burlap bags are recommended for all sandbag construction when available.

2. Fold the empty top of the bag at a 45-degree angle to keep sand from leaching out.

3. Place each bag over the folded top of the preceding bag and stomp into place.

4. Stagger the second layer of bags over the preceding layer seams.

5. Stomp all bags to form a tight seal.

6. The last sandbag in a line is referred to as a Key Sack. This bag is folded under and stomped into place.

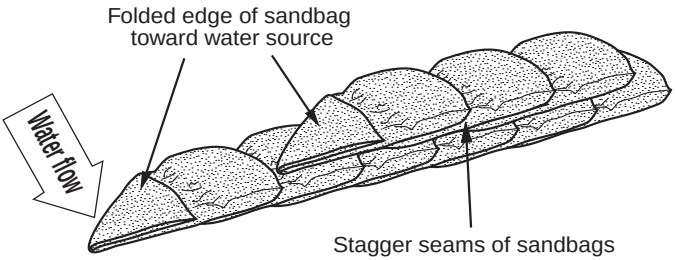


Figure 2
Fill sandbags 1/3 full, folded edge of sandbag toward water source, stagger seams of sandbags.

Tying Sandbags

Most sandbags are used with the open end folded. In some cases sandbags will have to be tied. Fill the bag 1/4 to 1/3 full of material. Hold one open corner (see Figure 3).

Figure 3

Figure 4

With your other hand take the lower portion of the opposite side and spin it

Figure 5

The long tail should be twisted tightly and look like a piece of rope.

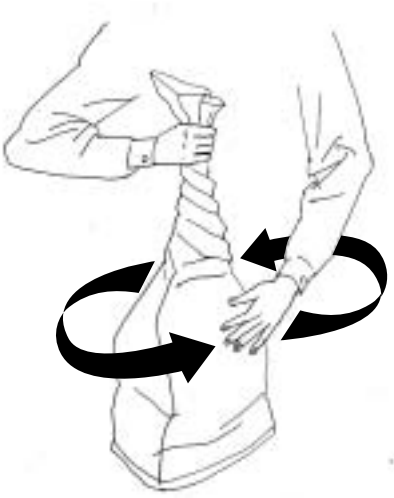


Figure 6

Tie an overhand knot (pretzel knot) as low as possible on the bag.

CONTROL OF LEVEE OVERTOPPING

If any levee reach is lower than the anticipated high water elevation, an emergency topping should be constructed to raise the levee grade to the forecast flood height. Levee topping may be required at road or stock crossings, low levee sections, or railroad crossings. The following paragraphs discuss various methods for increasing levee elevation.

Sack Topping

The most common form of flood control work is the use of sandbags for construction of temporary walls (see Figure 7). The use of sandbag walls to increase the height of a levee section is called “sack topping.” The sacks are laid “stretcherwise,” or along the levee for the first layer, crosswise for the the second layers, and so on. The sacks should be lapped at least one-third either way and stomped firmly into place. When properly sacked and tamped, one sack will provide about 3 to 4 inches of topping.

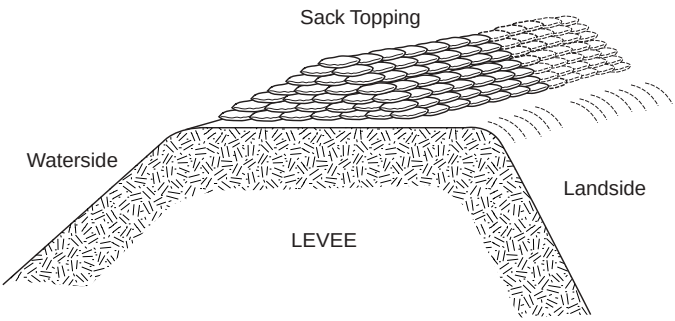


Figure 7

CONTROL OF BOILS (Away from Levee)

A boil is a condition that occurs when water is “piped” through or under a levee and resurfaces on the landside. These weak points are generally caused by burrowing rodents or decomposed tree roots. High water pressure can begin to erode the interior of the levee and weaken the structure. Levee material will deposit around the exit point as the water discharges on the landside. If the boil is determined to be **“carrying material”** then corrective action is required to control the situation. If left unattended the material that makes up the levee can be eroded at an accelerated pace, causing subsidence and overtopping of the levee. This could result in a levee break.

The common method for controlling a boil is to create a watertight sack ring around it. The sandbag structure should be high enough to slow the velocity and prevent further discharge of material from the boil (see Figure 8 and 8A). The flow of water should never be stopped completely, since this may cause the boil to “break out” in an area near the existing sack ring. A spillway must be constructed to direct water away from all boil sites.

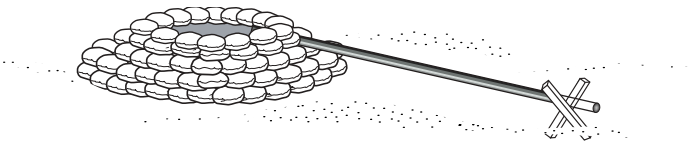


Figure 8
Bottom width should be at least $1^{1/2}$ times the height. Do not sack boils that are not carrying material, but continue to monitor. Boils can begin to carry material after first located.

The sack ring should be large enough to encompass the area immediately surrounding the discharge point (3 to 4 feet diameter). If several boils carrying material are found, a single large sack ring may be constructed around the entire “nest” of boils.

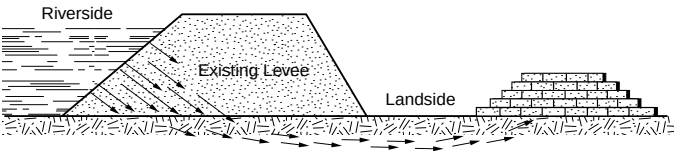


Figure 8A
NEVER completely stop the flow from a boil. This may cause the boil to “break out” in an adjacent area. ALWAYS control the boil to a point where it ceases to carry material and the water runs clear.

CONTROL OF BOILS (On Levee Slope)

If the boil is close to or on the levee slope, a U-shaped sack ring may be built around the boil and sealed into the slope (see Figure 8B). Construction of this method can be difficult and requires substantial shoring up of the U-shaped sack ring structure.

A spillway must be constructed to direct water away from all boil sites.

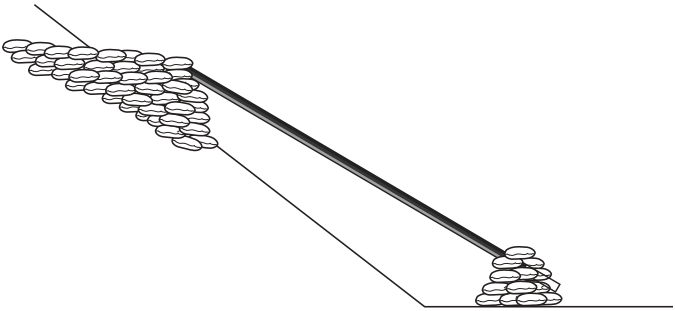


Figure 8B
Spillways can be constructed by nailing
two 2"x 6" boards together to form a V notch;
PVC pipe; two parallel sandbag rows; visquine, etc.

Waterside Boil Inlet Detection

Water running through a levee and carrying material can sometimes be stopped on the waterside, thus eliminating the building of sack rings on the landside (see Figure 9). A six foot long section of 2" diameter pipe secured to a 5'x 6' foot piece of plastic or canvas can be rolled over the inlet hole on the waterside. Drive 1"x 3"x 2' stakes into the shoulder of the levee. Suspend half filled sandbags on top of rolled-out material with twine and tie off to stakes.
It can be difficult to locate the waterside inlet of boils. Sometimes a swirl is observed at the water's edge.

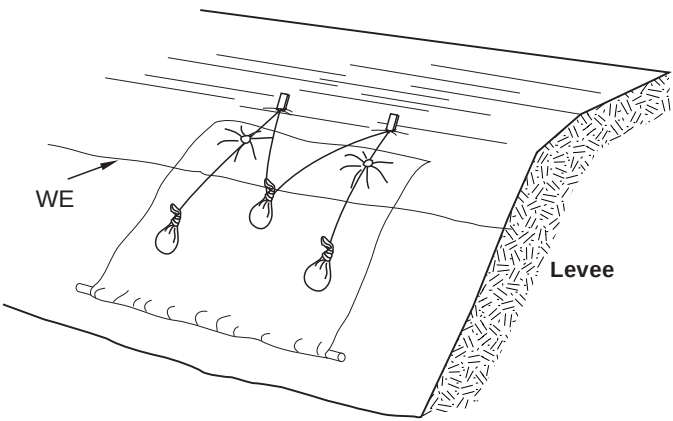


Figure 9

WAVEWASH PROTECTION

Wavewash

All levees adjacent to wide stretches of water should be watched during periods of strong wind to detect the early stages of wavewash erosion. If the slope is well sodded, short periods of high wind should cause little damage. However during sustained periods of strong wind and high water, ample labor should stand by, and experienced personnel should observe and monitor the effected areas.

Wavewash Protection

Envelope Method

When used correctly, plastic sheeting (Visquine) is useful for wavewash protection. Visquine should be purchased in rolls; 10 mil, 20 feet wide by 100 feet long. 1”x3”x2’ wooden stakes are driven into the ground just above the levee shoulder on the side you wish to protect. Place the stakes 4 feet apart and staggered 1 foot as shown in Figure 10.

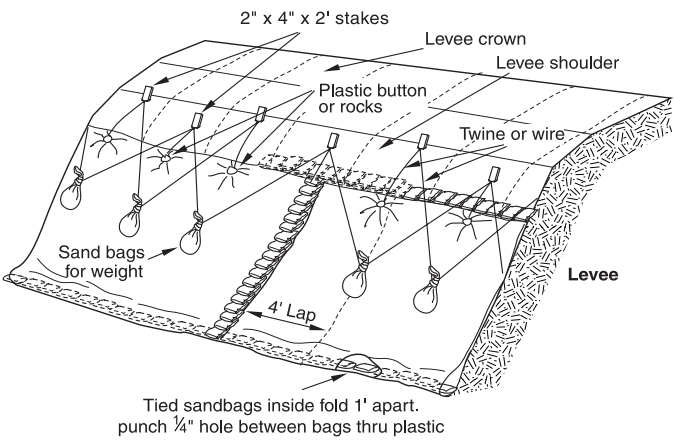


Figure 10
Wavewash Protection

Avoid driving stakes in a straight line; this tends to cause cracking and sloughing of the slope. To provide added strength and leverage, drive stakes at a slight angle away from the water source with the wide (3") side facing the water. Be sure the stakes are well into the ground and are secure.

When rolling out the plastic sheeting it is helpful to use a shovel or similar long-handled tool. Eight to ten people should assist in shaking out the folds of the envelope. Be sure that both layers are held while the envelope is shaken out. Hold on tight! Use caution in strong winds. If the wind catches the plastic it could billow out and pull you along with it.

While flood workers hold the plastic securely, toss tied sandbags into the envelope. The tied sandbags are thrown into the bottom of the envelope with a one-foot gap between bags. The tied bags provide weight to hold the plastic against the levee slope.

A tie-down button or small stone (preferably round) is secured through both layers of visquine. (If a stone is used, tie a slip knot and double half-hitch to secure it.) Fasten buttons to the visquine and tie off to the stakes using a minimum 250 lb tensil strength twine with these points in mind: (See Figure 10A.)

1. Fasten button at least 1 foot from the edge of the plastic.

2. Fasten buttons to both layers of plastic.

3. Fasten buttons directly below stakes (one button per stake).

4. Tie twine low on stake for strength and to prevent a tripping hazard.

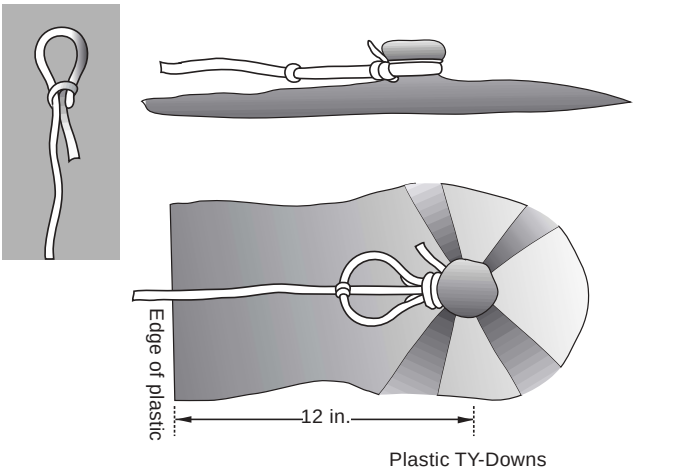


Figure 10A
Elimanate slipknot insert

Visquene is secured using tie down buttons. To attach plastic buttons to the visquene, tie a slipknot on the end of the twine; slip loop over button and plastic and draw tight. Tie two half hitch knots around the throat of main body. Extend twine to large end of main body, tie a half hitch knot around the end, and secure twine to stake. (see figure 10A)

With the visquine secured to the stakes, punch a small hole between each tied bag in the envelope, (a pencil works well). These holes release water trapped in the envelope. DO NOT use a knife because a slice or slit will tear and spread in the plastic.

If further slope protection is necessary insert an additional envelope into the existing wavewash protection overlapping at least four feet. To secure the overlap to the

stakes attach the two top layers with one button and the two bottom layers with another. The buttons line up with the stakes that are four feet apart. There should be four buttons securing the two envelopes.

Using a continuous piece of twine, hang tied-bags from stakes in a zigzag fashion as shown, in Figure 10. Tie a double half-hitch knot below the knot in each sandbag. Place each bag so that it hangs at the middle of the plastic directly below the stake between the two stakes from which it is suspended. Attach twine to every other stake with a double half-hitch. Add a second row of tied bags suspended from the stakes previously skipped. These bags will keep the visquine lying flat against the levee slope in windy conditions.

If the upper portion of the slope needs protection, use an additional envelope. Be sure to place the upper layer over the lower layer by 2 to 3 feet. Finally place sandbags along all seams to prevent wind and water from entering the envelope. To prevent slippage, make sure the top seam cap is half on the plastic and half on the levee as shown in Figure 10. If the levee slope is too steep, some of the bags on the seam may be tied off with twine to the stake above the envelope for support.

Remember, wind is your worst enemy. When using visquine, be sure all seams are secured with sandbags, and make needed repairs as soon as possible.

Protection of Slopes

Raincoat Method

The raincoat method is used to prevent further saturation of levee or hillside slopes. Visquine is laid out flat on the slope, and stakes are driven into the ground just above the area to be protected. The stakes are 4 feet apart with a 1-foot stagger. The visquine is secured to the stakes with tie-down buttons or small round rocks (see Figure 11).

Use a crisscross method of placing the sandbags (Figure 11) on the plastic. Place a solid row of sandbags on all edges of the visquine (half on ground, half on the visquine).

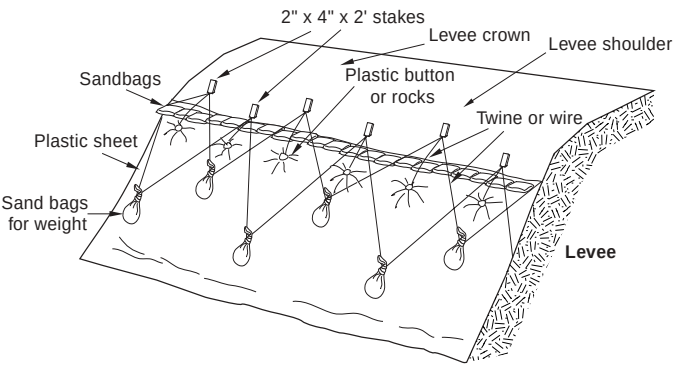


Figure 11

Temporary Levee

This method is used to raise low areas using plastic sheeting and fill material (sand, gravel, dirt, etc.) to prevent overtopping of levees, stream, river banks, small earthen dams, roadways etc. To raise low areas, unfold a 20'x100'x10 mil roll of visquine and lay out flat (see Figures 12).

Lay plastic flat on area to be raised. Place fill material (dirt, sand, gravel, etc.) on plastic. Fold plastic over material, lay a single row of sandbags on the backside lip of plastic and on all seams. Place fill material on the visquine using dump bed trucks, front-end loaders, or manually.

When this method is used in overtopping of small earthen dams, a spillway must be constructed.

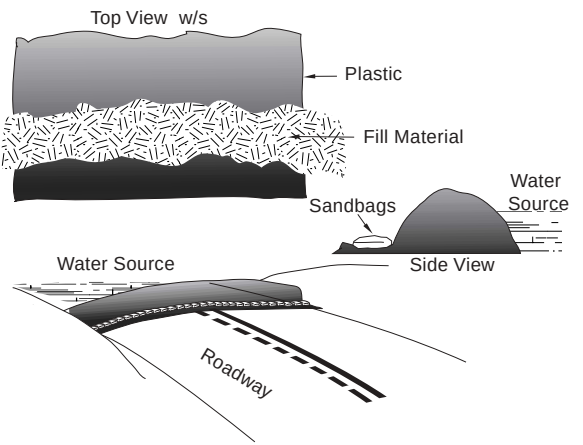


Figure 12

Wooden Panels

Many tools and materials are used in flood control efforts. A very versatile material is the wooden panel (see Figure 13). Wooden panels can be used for wavewash protection, lumber and sack toppings, and mud boxes. Wooden panels should be prefabricated and can be easily transported to the work site. The panels are generally 3 feet high with a minimum length of 12 feet. They are made of 1" x 12" x 12' boards The boards are nailed to 1" x 4" x 3' slats at 6-foot intervals. A 1/4 inch gap is left between each board in the panel.

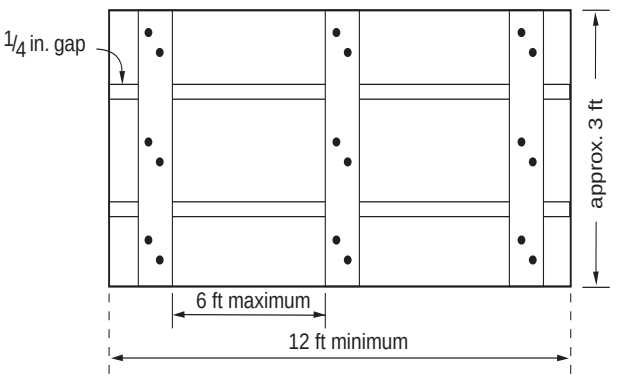
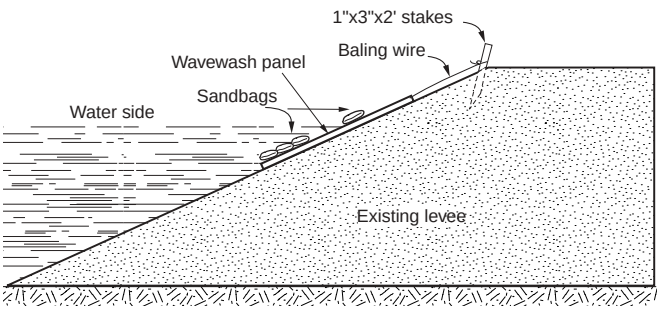


Figure 13

Wooden Panel Wavewash Protection

Although visquine is the preferred method of wavewash protection, wooden panels can be used (see Figure 14). When the water current is very fast or swift, wooden panels will hold up better than plastic sheeting. Drive wooden stakes (1" x 3" x 2') into the levee shoulder in the same manner as visquine (4 ft apart with a stagger of 1 ft between rows).

Baling wire is tied to the wooden panels through the 1/4 inch gap between the 1"x 12" boards. Sandbags are wired to the bottom half of the panels to weigh them down. Push the panels into the water with pike poles. The baling wire is then tied to the stakes as low as possible. Adjust the length of the baling wire to secure the panels in the proper position. If more panels are added, the overlap area must be 1 foot and facing downstream. One or more panels can be wired together if more than 3 feet of slope protection is needed.



NOTE: Panels may be placed in a vertical position, depending on existing conditions.

Figure 14

Lumber and Sack Topping

With this method, wooden panels are used on the waterside shoulder and reinforced on the opposite side with sandbags. The method is used to raise low reaches during high water (see Figure 15). Stakes 2"x 4"x 6' should be driven on the waterside shoulder 6 feet apart. Dig a shallow trench and line it with empty sandbags to provide a seal. Pre-constructed wooden panels are placed in the trench and nailed to the landside of the stakes. This wall should then be backed with enough sandbags to support the panels against the expected high water. In some cases, it may be practical to back the panels with tamped earth in lieu of sandbags. Attach 2"x 4"x 10' lumber kickers to the stakes that support the panels, and drive 2' stakes into the levee crown. Use at least two nails at each joint to ensure rigid construction.

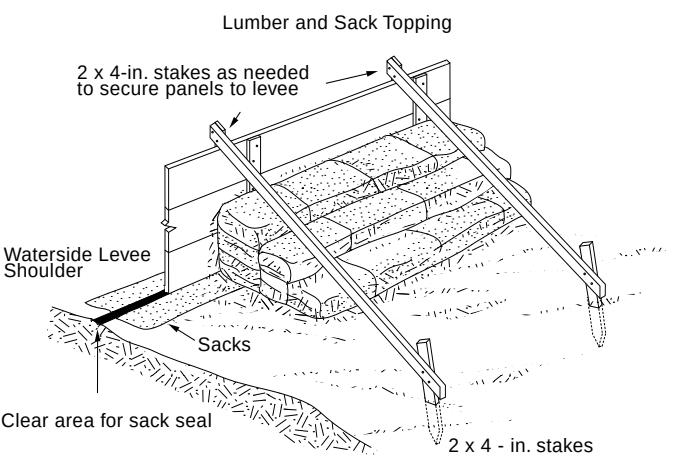


Figure 15

Mud Boxes

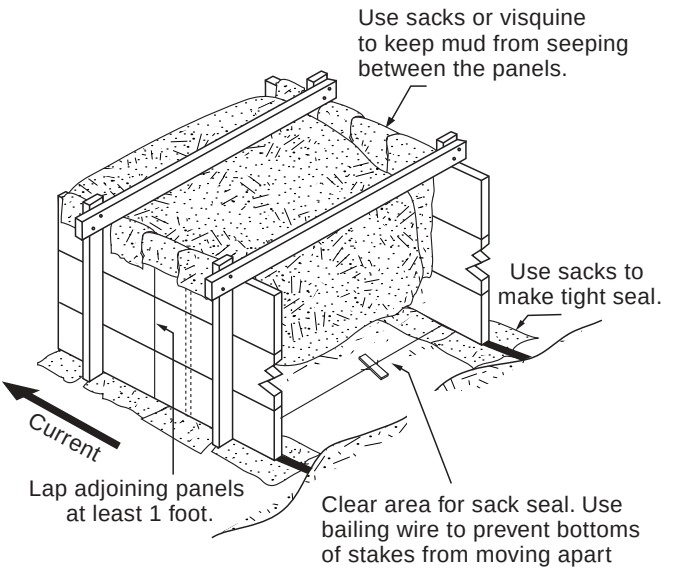
With this method, two parallel wooden walls are placed and supported near the waterward levee shoulder and filled with available material (see Figure 16). Spacing of the walls will vary with height but should be proportional to a box 3 feet high and 30 inches wide.

Mud boxes may be used when the available fill material is too wet for a sandbag sack topping, providing the boxes are lined with canvas, visquine, or burlap. If visquine is used, punch pencil-size holes in the bottom of the visquine to allow water to seep out. Close the open ends of the mud box with sandbags and tie into high ground.

NOTE

Mud boxes can also be used to divert mud flows from structures. If it is used for this purpose, plywood should be nailed to the face of the mud box, thereby creating a smooth surface.

(See Figure 16 on next page)


Use sacks or visquine
to keep mud from seeping
between the panels.
Use sacks to
make tight seal.
Current
Lap adjoining panels
at least 1 foot.
Clear area for sack seal. Use
bailing wire to prevent bottoms
of stakes from moving apart

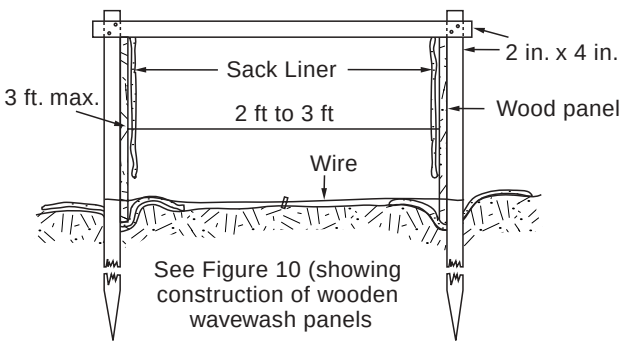

2 in. x 4 in.
Sack Liner
3 ft. max.
2 ft to 3 ft
Wood panel
Wire
See Figure 10 (showing
construction of wooden
wavewash panels

Figure 16

Emergency Spillway Using Visquine and Sandbags

Place plastic sheeting over area to be used for spillway. Line all sides with at least a single row of sandbags. Tie in *Sack Topping* sandbag wall at top of structure on both sides to high ground. Use additional tied sandbags on plastic for weight if needed.

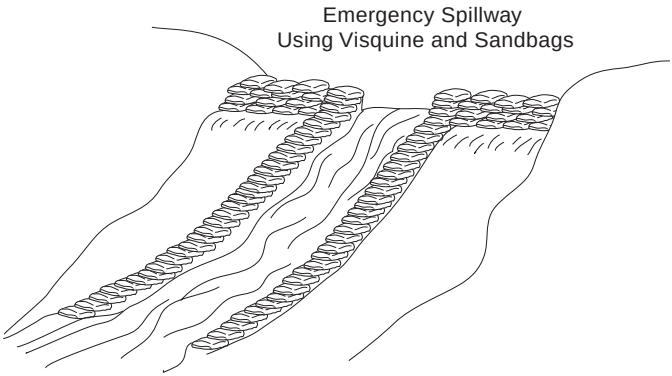


Figure 17

METHODS OF FLOOD FIGHTING AROUND STRUCTURES

The main causes of damage to structures, homes and property during heavy rains or flood flows are:

1. Flood water from overwhelmed storm drains and urban diversions, particularly on sloping streets.

2. Flood flows onto property through driveway openings, and low spots in curbs.

3. Debris flow from hillsides that have been cleared of vegetation by fire or real estate development.

The flood fighting methods described in the following paragraphs have proved effective in combating floodwaters and flood flows.

Diverting Water Away from Homes

To prevent or reduce property damage, the following methods can be effective.

Homes and structures can be protected from floodwater by redirecting the water flow as shown in Figure 18. Sandbag or wooden barriers must be placed at an angle and must be long enough to divert the flowing water away from all structures.

Barriers constructed of sandbags or lumber can also be used to channel mud and debris away from property improvements.

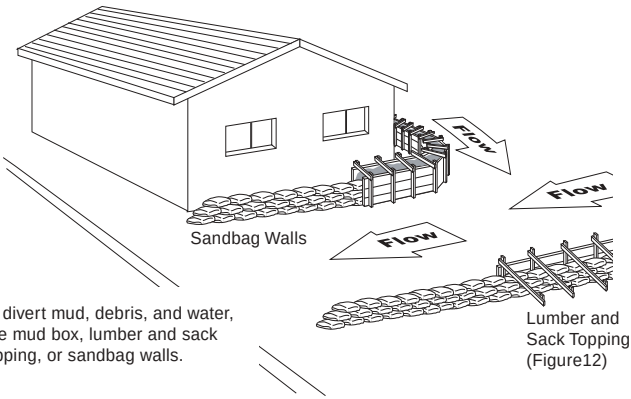


Figure 18

Home / Structure Protection

The following method is used for protection of buildings and other structures along lake shores and in similar situations where water is rising with little or no current.

Lay plastic sheeting on the ground and up the building walls to a point at least 1 foot above the predicted water elevation, and far enough out on the ground to form a half pyramid of sandbags (see Figure 19). Secure plywood over doors and vents. Overlap visquine and sandbags at corners of buildings.

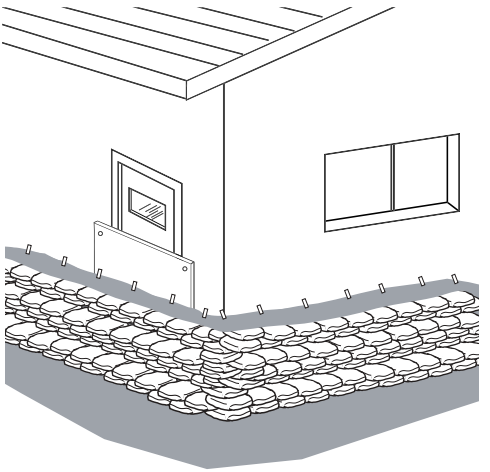
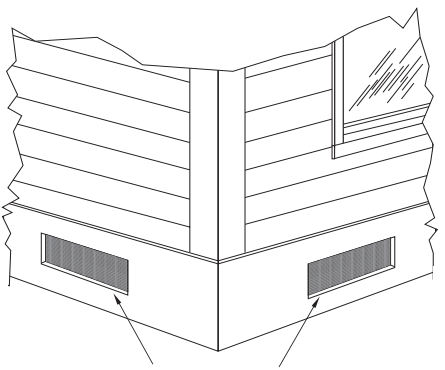


Figure 19

Wet Flood Proofing Requirements for Structures Located Within Special Flood Hazard Areas

National Flood Insurance Program regulations require that buildings on extended wall foundations or that have enclosures below the base flood elevation must have foundation or enclosure wall openings. These openings prevent the foundation or enclosure walls from weakening or collapsing under pressure from hydrostatic forces during a 100 year flood event. The openings allow flood waters to reach equal levels on both sides of the foundation or enclosure wall and minimize the potential for damage from hydrostatic pressure.



Foundation or wall openings must be kept open within special flood hazard areas

Figure 20

<u>These Openings Must Not Be Blocked If The Building Is Located Within A Special Flood Hazard Area.</u>

For details refer to FEMA Technical Bulletins TB1-93 and TB-7. These bulletins may be obtained from the FEMA web site at: *http://www.fema.gov*

For additional information contact DWR Floodplain Management at (916) 653-9902.

Protection of Water or Sewer System

Water or sewer systems can be protected by placing corrugated metal pipe (CMP) over the manhole (see Figure 21). Lay visquine up the walls of the CMP and place sandbags in the form of a half pyramid around the CMP to seal it to the pavement. This method will prevent mud and debris from entering the system and also act as a surge chamber.

Using corregated metal pipe (CMP) over manhole to isolate sewer line or prevent contamination of water system.

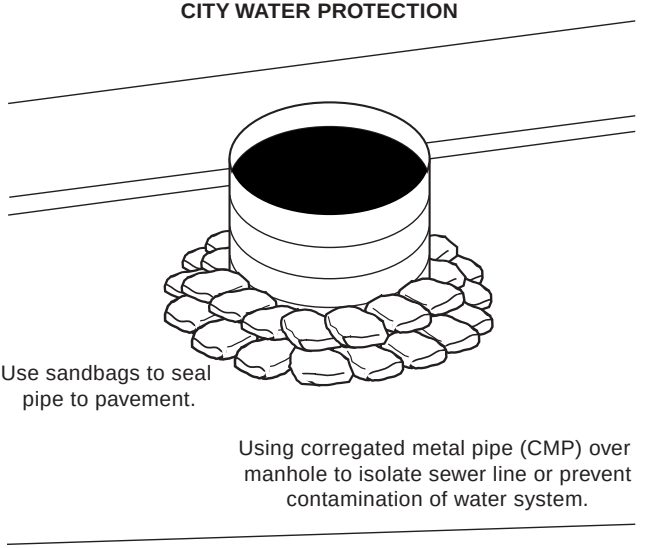


Figure 21

FLOODFIGHT SAFETY

Numerous potential hazards exist during flood events. These hazards are manageable if identification and communication occurs on an ongoing basis. Personal safety requires a conscious effort that every flood fighter must consider in their various duties and activities.

- Changing Weather Patterns: This occurrence can affect existing conditions and create more serious situations. Always know the forecast and how it affects vulnerable areas, workers and the public.

- Changing Water Patterns: The rise and fall of water can occur gradually or very quickly. Knowledge of high water and how it relates to levees, communities and workers is essential. Continuous monitoring and communication of water level influences, (i.e. reservoir releases, tides and drainage inflow) is very important. Always know your area and the *flood history* around you.

- Swift Water: High velocities of water are common during flooding events. Extreme caution should be used when anyone is exposed to high water. Workers should have floatation devices, throw ropes and lifelines in the immediate area. Swift water rescue teams may be available. Use common sense and sound judgement around swift water. Know your resources and how to activate them prior to the event.

FLOODFIGHT SAFETY

- Climate Related Illness: During a flood fight, weather patterns can change constantly. Climate changes present the potential for hypothermia and heat prostration. Flood fighters should know the signs of distress for these types of illnesses and how to treat them. During cold, wet weather it is recommended that workers layer clothing, stay warm and dry. A dry blanket and warm clear fluids should be on the work site for emergency use. In warm, hot weather lightweight clothing is recommended. If skin is exposed, a sun block agent may need to be applied. Plenty of drinking water should be on site and consumed regularly. In both hot and cold situations headgear is recommended.

- Insect/Animal Exposure: Flooded areas force a variety of animals to evacuate to high ground. Workers in these areas should be aware of these animals or reptiles and not handle them. If animal removal is needed, contact a local professional. Stinging and biting insects are prominent in certain flood prone areas. Chemical repellents can be useful as a deterrent. A complete first aid kit should be on site.

- Sandpile Safety: When shovels are used for filling bags a safe distance for workers is essential. Sandbags and sand may contain contaminates. Have disinfectant available. Safety glasses or goggles are recommended for protection from blowing sand particles.

FLOODFIGHT SAFETY

- Contamination: Flooded areas can potentially carry high levels of contaminants. Local Haz-Mat teams should be contacted if needed. Always wear protective clothing to help limit contact with water. Carry antibiotic hand soap and wash thoroughly after working around floodwater.

- Exhaustion: Stress combined with long, physically demanding hours can have an adverse effect on the flood worker. It is very important to recognize exhaustion or sleep deprivation and treat them immediately. Operation of vehicles, machinery or equipment should be avoided. A shift rotation of personnel will help eliminate fatigue factors.

- Body Mechanics: Proper body mechanics while working on floods is very important. The body is expected to work long, physical, hours during the event. Each individual most make a conscious effort to use safe lifting and weight distribution techniques. Watch your footing, surfaces can be slippery and cluttered with tripping hazards.

- Construction Equipment: There are times when equipment and people will occupy the same work area. Workers should wear safety vests, hard hats and be aware of their surroundings. Safety warning devices, (i.e. backup alarms and lights) should be in-tact and working on all equipment. Communication and alertness is vital! All operators must be certified for their equipment.

FLOODFIGHT SAFETY

- Boat travel: Materials and/or personnel will sometimes need to be transported to work sites by boat. Operators of the watercraft must be certified. Floatation devices must be available for every passenger. Extreme care should be taken while loading and off loading. Watchful eyes are needed.

- Patrolling: Patrolling is the key to effective floodfighting. Patrols will identify, initiate control and monitor trouble spots in affected areas. Vehicle patrols should travel in two person teams with dependable communication devices. Lifelines, floatation devices and a blanket should be in the vehicle for possible water related accidents. Foot patrols should also have the same considerations. Extreme caution should be exercised when travelling saturated, cracking or sluffing areas.

- Vehicle Placement: Vehicles in work areas along the levee should remain parked on high ground. This is usually the crown roadway. Vehicles should also be parked facing their access point. An escape plan should be communicated to all flood workers.

- Structure Considerations: When working around structures, be aware of downed power lines, natural gas or propane leaks and unstable structure supports. Communicate with the structure owner if possible.

- Safety Gear: Rain gear, warm clothing, handheld lights, gloves, goggles, hardhat, boots, first aid kit, ropes, floatation devices, hip boots.

FOR ADDITIONAL INFORMATION CONTACT:

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